CLAIMS

1. A method of manufacturing a thin film transistor including an oxide film, the method comprising the oxide film forming step of

immersing a substrate in an oxidizing solution containing an active oxidizing species for direct oxidation of the substrate to form a chemical oxide film, the substrate having a surface on which a chemical oxide film is to be formed.

2. The method of claim 1, wherein

in the oxide film forming step, the active oxidizing species is formed by heating the oxidizing solution or electrolyzing the oxidizing solution.

3. The method of either one of claims 1 and 2, wherein in the oxide film forming step,

the substrate is immersed in the oxidizing solution of different concentrations, and

the concentration of the oxidizing solution is altered from a low-concentration oxidizing solution to a high-concentration oxidizing solution.

4. The method of either one of claims 1 and 2, wherein:

the low-concentration oxidizing solution has a lower concentration than an azeotropic concentration; and

the high-concentration oxidizing solution has the azeotropic concentration.

5. The method of any one of claims 2, 3, and 4, wherein

in the oxide film forming step, the low-concentration oxidizing solution is concentrated to prepare the high-concentration oxidizing solution.

6. The method of either one of claims 1 and 2, wherein

in the oxide film forming step, the chemical oxide film is grown on the substrate surface by applying voltage to the substrate on which the chemical oxide film is to be formed.

7. The method of any one of claims 1 to 6, wherein

the substrate on which the chemical oxide film is to be formed contains, on the surface, at least one component selected from the group consisting of monocrystal silicon, polycrystalline silicon, amorphous silicon, continuous grain silicon, silicon carbide, and silicon germanium.

8. The method of any one of claims 1 to 7, wherein

the oxidizing solution contains: at least one solution selected from the group consisting of nitric acid, perchloric

acid, sulfuric acid, ozone-dissolving water, aqueous hydrogen peroxide, a mixed solution of hydrochloric acid and aqueous hydrogen peroxide, a mixed solution of sulfuric acid and aqueous hydrogen peroxide, a mixed solution of aqueous ammonia and aqueous hydrogen peroxide, a mixed solution of sulfuric acid and nitric acid, aqua regia, and boiling water; a gas thereof; or a mixed solution thereof.

9. The method of claim 7, wherein

the oxidizing solution is an azeotropic mixture.

10. The method of claim 9, wherein

the oxidizing solution contains at least one solution selected from the group consisting of azeotropic nitric acid which is an azeotropic mixture with water, azeotropic sulfuric acid which is an azeotropic mixture with water, and azeotropic perchloric acid which is an azeotropic mixture with water.

11. The method of any one of claims 1 to 10, wherein

the oxide film forming step is carried out at 200°C or lower temperatures.

12. The method of any one of claims 1 to 11, further comprising, after forming the chemical oxide film, the step of

forming an insulating film on the chemical oxide film.

13. The method of either one of claims 1 and 2, wherein

the oxide film forming step comprises the steps of:

immersing the substrate in an oxidizing solution below azeotropic concentration to form a first oxide film; and

concentrating the oxidizing solution below azeotropic concentration up to an azeotropic concentration with the substrate being immersed in that oxidizing solution to form a second oxide film on the first oxide film.

14. The method of claim 7, wherein

the substrate on which the chemical oxide film is to be formed contains silicon carbide on the surface.

15. The method of claim 8, wherein

the oxidizing solution is nitric acid.

16. The method of any one of claims 1 to 15, further comprising, after the oxide film forming step, the step of subjecting the chemical oxide film(s) to nitriding.

17. A thin film transistor manufactured by the method of any one of claims 1 to 16, comprising the chemical oxide film formed by oxidation in an oxidizing solution.

18. A thin film transistor of claim 17, wherein the chemical oxide film has a relatively high atomic density near the substrate.

19. The thin film transistor of either one of claims 17 and 18, wherein

the chemical oxide film is a gate oxide film.

20. A display containing the thin film transistor of any one of claims 17 to 19.

21. A method of modifying an oxide film, comprising the step of

performing the oxide film forming step of any one of claims 1 to 16 on an oxide film having a non-uniform thickness to improve quality of the oxide film.

22. A method of modifying an oxide film, comprising the step of

performing the oxide film forming step of any one of claims 1 to 16 on an oxide film having non-uniform quality to improve the quality of the oxide film.

23. A method of forming an oxide film, comprising the steps

of:

bringing a semiconductor in contact with an oxidizing solution below azeotropic concentration or a gas thereof to form a first chemical oxide film on a surface of the semiconductor; and

bringing the semiconductor on which the first chemical oxide film is formed in contact with an oxidizing solution of azeotropic concentration or a gas thereof to form a second chemical oxide film.

24. A method of forming an oxide film, comprising the steps of:

reacting an oxidizing solution of a low concentration or a gas thereof with a surface of a semiconductor to form a first chemical oxide film on the surface of the semiconductor; and

reacting an oxidizing solution of a high concentration or a gas thereof to form a second chemical oxide film on the first chemical oxide film.

25. The method of either one of claims 23 and 24, wherein

the step of forming the second chemical oxide film is carried out while the oxidizing solution used to form the first chemical oxide film is being concentrated.

26. The method of any one of claims 23, 24, and 25, wherein

the second chemical oxide film is formed so that the second chemical oxide film is thicker than the first chemical oxide film.

27. The method of any one of claims 23 to 26, wherein

the step of forming the first chemical oxide film and the step of forming the second chemical oxide film are carried out with the semiconductor being immersed in the oxidizing solution.

28. The method of any one of claims 23 to 27, wherein

the semiconductor contains at least one component selected from the group consisting of monocrystal silicon, polycrystalline silicon, amorphous silicon, silicon carbide, and silicon germanium.

29. The method of claim 24, wherein

the oxidizing solution of a high concentration or a gas thereof is an oxidizing solution of azeotropic concentration or a gas thereof.

30. The method of any one of claims 23 to 29, wherein

the oxidizing solution or the gas thereof contains: at least one solution selected from the group consisting of nitric acid, perchloric acid, sulfuric acid, ozone-dissolving water,

aqueous hydrogen peroxide, a mixed solution of hydrochloric acid and aqueous hydrogen peroxide, a mixed solution of sulfuric acid and aqueous hydrogen peroxide, a mixed solution of aqueous ammonia and aqueous hydrogen peroxide, a mixed solution of sulfuric acid and nitric acid, aqua regia, and boiling water; a gas thereof; or a mixture thereof.

31. The method of claim 24, wherein:

the oxidizing solution of a low concentration or the gas thereof contains: at least one solution below azeotropic concentration selected from the group consisting of an aqueous solution of nitric acid, an aqueous solution of sulfuric acid, and an aqueous solution of perchloric acid; or a gas thereof; and

the oxidizing solution of a high concentration or the gas thereof contains: at least one solution of azeotropic concentration selected from the group; or a gas thereof.

32. The method of any one of claims 23 to 31, further comprising, after forming the chemical oxide films on the surface of the semiconductor, the step of subjecting the chemical oxide films to nitriding.

33. A method of manufacturing a semiconductor device, comprising the oxide film forming step of

forming a chemical oxide film by the method of any one of claims 23 to 32.

34. A method of manufacturing a semiconductor device, comprising the steps of:

reacting an oxidizing solution of a low concentration or a gas thereof with a surface of a semiconductor to form a first chemical oxide film on the surface of the semiconductor; and

reacting an oxidizing solution of a high concentration or a gas thereof to form a second chemical oxide film on the first chemical oxide film.

35. The method of claim 34, wherein:

the oxidizing solution of a low concentration or the gas thereof contains a mixture below azeotropic concentration selected from the group consisting of mixtures of water and at least one of nitric acid, perchloric acid, and sulfuric acid; and

the oxidizing solution of a high concentration or the gas thereof contains a mixture above the low concentration selected from the group.

36. The method of either one of claims 34 and 35, wherein

the oxidizing solution of a high concentration or the gas thereof contains: at least one solution selected from the group consisting of azeotropic nitric acid which is an azeotropic

mixture with water, azeotropic sulfuric acid which is an azeotropic mixture with water, and azeotropic perchloric acid which is an azeotropic mixture with water; or a gas thereof.

37. The method of any one of claims 34 to 36, wherein

the semiconductor contains at least one component selected from the group consisting of monocrystal silicon, polycrystalline silicon, amorphous silicon, silicon carbide, and silicon germanium.

38. The method of any one of claims 34 to 37, further comprising, after forming the chemical oxide films on the surface of the semiconductor, the step of subjecting the chemical oxide films to nitriding.

39. The method of any one of claims 34 to 38, further comprising, after forming the chemical oxide films on the surface of the semiconductor or after subjecting the chemical oxide films to nitriding, the step of forming, as a coating film, at least one of an oxide film made by chemical vapor deposition (CVD), a silicon nitride film, a high dielectric film, and a ferroelectric film.

40. A semiconductor device manufactured by the method of any one of claim 33 to 39, comprising the chemical oxide film

formed by oxidation of the semiconductor in the oxidizing solution.

41. An apparatus for manufacturing a semiconductor device, comprising:

a function of reacting an oxidizing solution of a low concentration or a gas thereof with a surface of a semiconductor to form a first chemical oxide film on the surface of the semiconductor; and

a function of reacting an oxidizing solution of a high concentration or a gas thereof to form a second chemical oxide film on the first chemical oxide film.

42. An apparatus for manufacturing a semiconductor device, comprising

an oxide film forming section for forming a chemical oxide film on a surface of a semiconductor,

wherein the oxide film forming section has a function of forming the chemical oxide film on the surface of the semiconductor by the method of any one of claims 23 to 32 or the method of any one of claims 33 to 39.